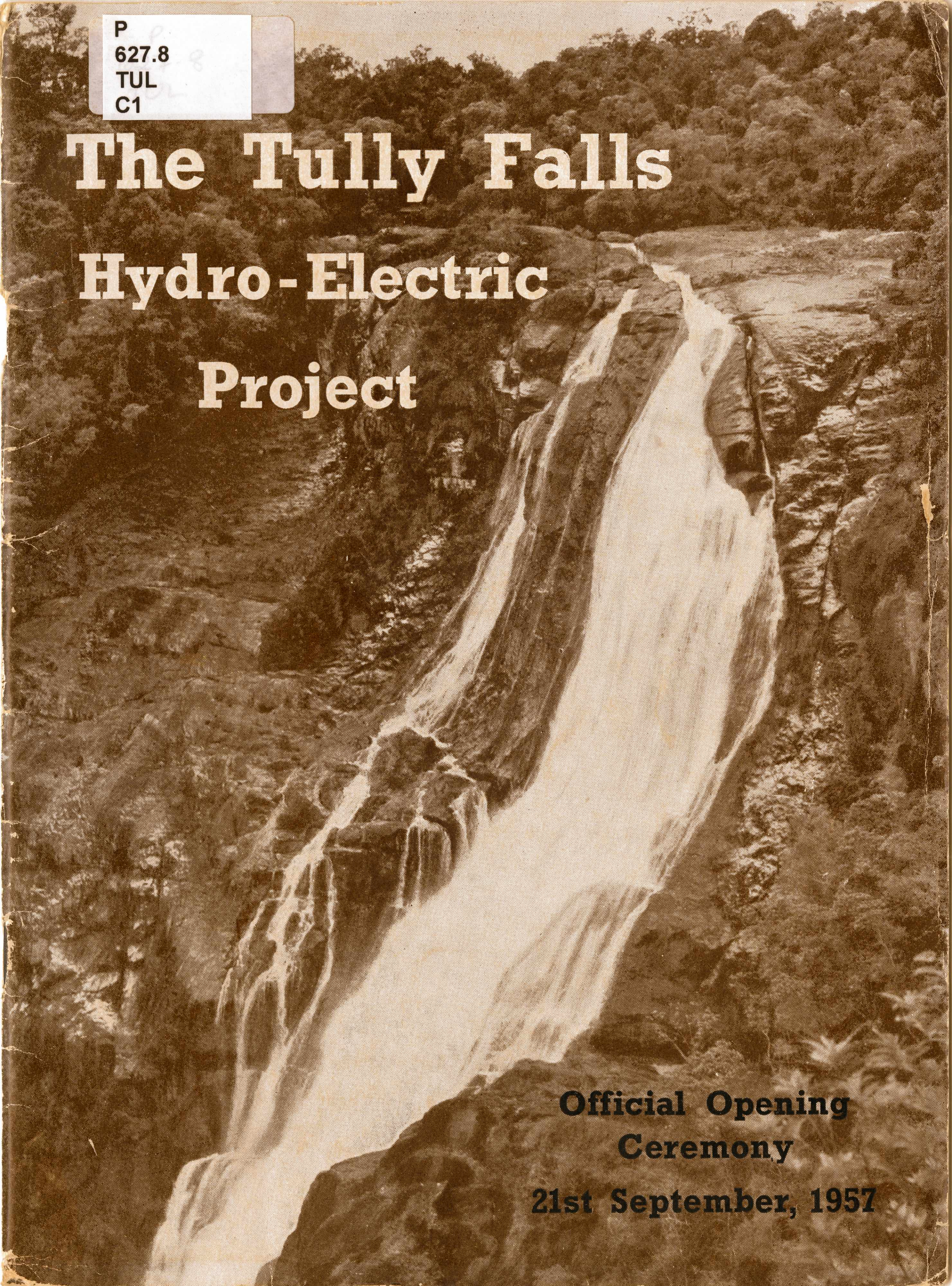
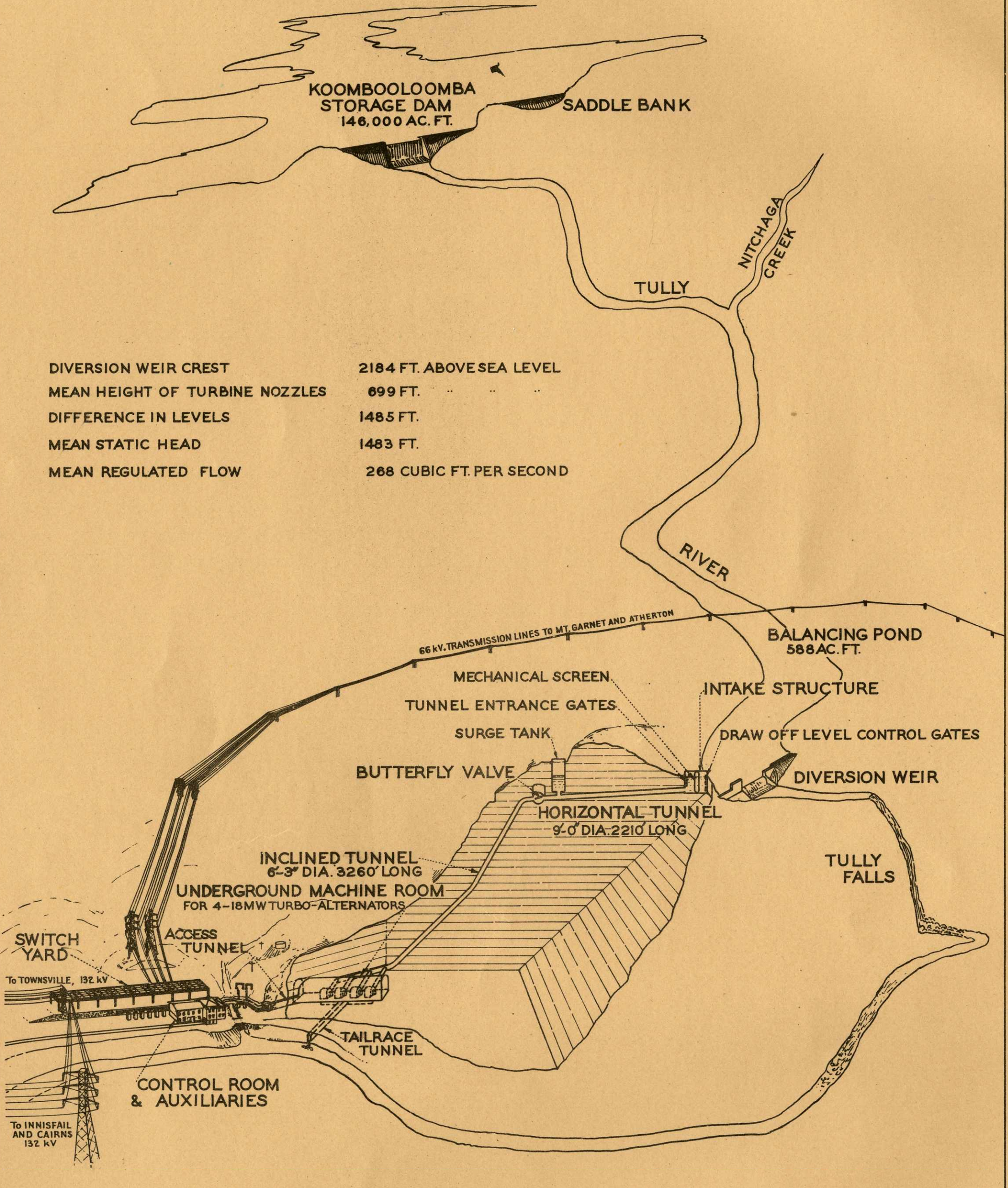
The Tully Falls Hydro-Electric Project



Official Opening Ceremony

21st September, 1957



TULLY FALLS HYDRO ELECTRIC PROJECT
A PICTORIAL REPRESENTATION

T26

Department of the Co-ordinator General
Queensland

Foreword

A power project which will supply an area more than half the size of Victoria is a gigantic task. This is what the Tully Falls Hydro-electric Project is estimated to do when the initial construction stage is completed.

The scheme is now producing its first electric power to benefit the people of the North. More than £12 million has been spent to bring the project to its present stage, and an estimated £6 million will be required in the next three years to finish the main Tully Falls-Kareeya portion with all its associated works.

Electric power is a basic requirement of modern living, and power from Tully Falls will do much to meet the growing demands for an ever-increasing supply. Queensland is on the threshold of great and rapid development, and it is the Government's objective to see that this growth is not hindered by power insufficiency.

I congratulate all who have been responsible for turning the great Tully Falls project from a drawing-board dream into a vital reality.

This booklet tells the full story of the Tully Falls Hydro-electric Project, and I commend it to you.

Premier of Queensland.

THE TULLY FALLS HYDRO-ELECTRIC PROJECT.

Preliminary Investigations.

The Queensland Government decided early in 1950 to proceed with the first stage of the Tully Falls Hydro-electric Project following careful investigations of North Queensland rivers from the Barron to the Herbert.

A general requirement of electrical energy is that it should be available whenever needed, or "firm". For "firm" hydro power generation, essentials are a reliable supply of adequate water and a difference in level, or "head".

Few areas in Queensland provide these conditions. Most of the hydro-electric power potential in the State—estimated at nearly half a million horsepower—is concentrated in a narrow belt of very wet, elevated country near the east coast of North Queensland.

Here there are some half-dozen rivers which may be developed eventually, but careful investigations of their water resources and the methods by which power could be developed from them, indicated that the upper Tully was the most favourable for early development.

Examination was made of the comparative economics of generation by water-power from the Tully River, for which there were two alternative schemes—known as the Tully Falls Scheme and the Cardwell Range Scheme respectively—and by coal or oil-burning stations nearer to the centres in which the power would mainly be used.

It was found that the construction of a power station a short distance below Tully Falls would show the greatest ultimate economy. A new steam station more centrally placed in the region would have been cheaper in its first cost, but the hydro station promised to give cheaper power in the long run.

Power Station Centrally Located.

The location of the power station is reasonably central to the load centres of the Tableland, Cairns, Innisfail and Mt. Garnet with its tin dredges, and not unfavourably placed for linkage to Townsville.

Upper Tully River and the Falls.

Tully River rises in the Cardwell Range at an elevation of some 3,000 feet. The whole of the catchment has a very high rainfall, ranging from an average of 70 inches per annum at Tully Falls to, perhaps, 150 inches in the Cardwell Range. The average annual mean value over the catchment is probably between 90 and 100 inches.

The greater part of the upper Tully catchment is covered by dense rain forest, which merges on the western side into open forest. The area is not considered well-suited for settlement, and has been reserved for forestry purposes. This is a further advantage for hydro power development, since diminution of its water-yielding capacity need not be anticipated.

At the head of the falls, the river is about 2,160 feet above sea level. The first section of the falls is about 700 feet, but the river continues to fall rapidly for the first two miles, and flows seaward through a gorge about 2,000 feet deep.

The area of the catchment above Tully Falls is some 100 square miles, and the average flow of the river at the falls is 500 cubic feet per second (cusecs.). This flow has, however, been very variable; the maximum flow in 1927 exceeded 30,000 cusecs., while the minimum was probably about 10 cusecs. at the end of the 1946 drought.

Koombooloomba Dam.

The storage dam at Koombooloomba will serve to regulate the river and to ensure that an average flow of not less than 268 cusecs. will be always available at the diversion point for the hydro-electric plant. Provision has been made to ensure that flow over the falls will be maintained.

PROGRESSIVE DEVELOPMENT PLANNED.

Development of the hydro-electric power potential of the Tully River was originally planned in three stages, of which the present project covers the first—

(i.) The Tully Falls section and Kareeya Power Station to have an installed capacity of 72,000 kW (kilowatts) of generating plant. The power station is now largely in service, and it is expected to be fully operational early in 1958;

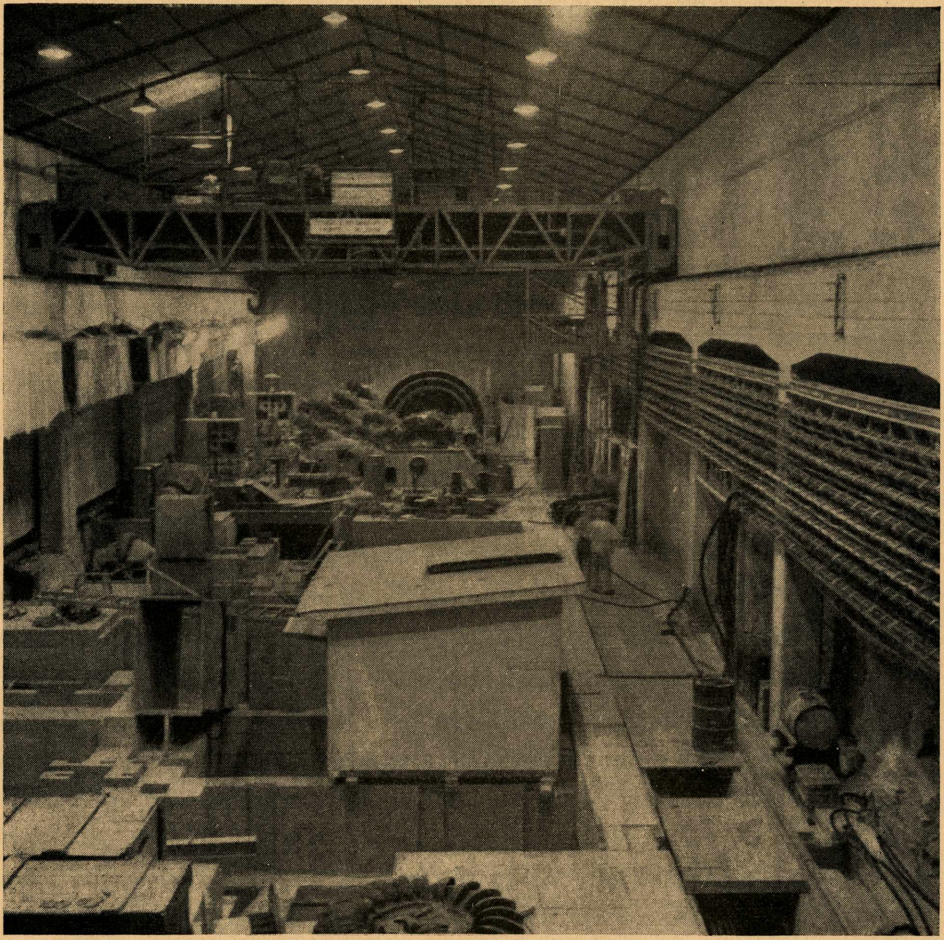
(ii.) The Tully-Cochable extension section which will take advantage of additional head due to the fall in the river below the Kareeya Power Station and again use the water discharged from its turbines; and

(iii.) The Tully-Nitchaga section.—This will utilise the head of water in the Koombooloomba Storage Dam, together with the fall in the river between the dam and the point above the falls at which the the water is diverted to the Kareeya Power Station.

The original authorisation in 1950 covered partial development of the first stage. At that time, it seemed that for many years power would be supplied only to the Cairns Region, and the installation of no more than two 18,000-kW turbo-generators of a total of four, then appeared to be justified. However, the rapid increase in load in the Townsville area and the high cost of coal led to a revision of the first stage before its completion. In April 1955, the installation of the two additional 18,000-kW sets and the construction of a 132-kV transmission line to link the new station with Townsville were authorised as an extension.

TULLY FALLS—KAREEYA SECTION.

The Tully Falls-Kareeya section which has recently been completed except for the installation of the third and fourth generating sets, uses a fall of approximately 1,500 feet in the river over a distance of some two miles between the diversion



Underground Machine Room, Kareeya—Erection of Turbo-Generators.

weir site, which is about half a-mile above the falls, and the power house site—Kareeya—in the gorge below. Between these points the river follows a horseshoe bend, and this has allowed water to be diverted into the power station through tunnels which are only about one mile in length.

In order that the generation of power will be continuous, the fluctuations in the flow of the river must be smoothed out by storing water when the river discharge is high, and releasing it at a steady rate as required. Koombooloomba Dam will form the main storage and is an integral and essential part of the scheme.

The project is illustrated by the pictorial representation on the flyleaf.

Koombooloomba Dam.

Koombooloomba Dam is about seven miles above the falls, near the junction of Monday Creek with the Tully River. The aboriginal name of Koombooloomba, meaning "Place of Gold", has been taken from Koombooloomba Creek nearby.

The dam has some unorthodox features, and its design has been greatly influenced by site conditions. The bed of the river consists of granite rock somewhat fissured but predominately sound and unweathered. This unweathered rock does not continue appreciably above bed level in the sides of the valley.

To conform with these conditions the dam will comprise a central spillway section some 200 feet long and about 115 feet above the original stream bed, founded on rock, with earth and rock fill flanks, supported by longitudinal concrete retaining walls, roughly parallel to the river, just clear of the banks.

The reservoir will have a total capacity of some 152,000 acre feet of water, or 41,000 millions of gallons. About 146,000 acre feet will be available above the outlets, which will consist of two 7-feet 6-inch diameter pipes controlled by 6-feet diameter regulating valves.

The area of the reservoir at normal full supply level will be about 3,750 acres.

In addition to the main dam, two supplementary dams of rolled earth are required to close low saddles on the rim of the catchment. The larger saddle dam was completed in December, 1955.

When completed, Koombooloomba Dam and its reservoir will ensure that the required volume of water is always available for the generation of power.

Water Demand at Variable Rates.

Water is required by the turbines at very variable rates. The water demand depends on the drain on electric power which varies greatly throughout the day. The maximum demand for power may be about double the average. During peak hours the rate of water flow to the turbines may be many times that during the night.

Dual Purpose Weir.

To even fluctuations in the flow, a balancing pondage is provided by a low concrete weir about half a-mile above Tully Falls. This serves the dual purpose of diverting the water into an intake structure, and provides a balancing storage. Gates in the weir allow release of water to the falls when desired.

Intake Structure.

A reinforced concrete intake structure is designed to exclude sand and gravel as far as possible, and to divert water into the tunnel. It also houses protecting gates which can cut off the flow if required. Mechanical screens are provided to remove floating leaves and other debris.

Control of Water to Power Station.

From the intake the water first flows through the ridge separating the upper reaches of the river from the lower gorge in a 9-feet diameter steel-lined tunnel. This is a little over 2,200 feet long, and has only a very slight slope. This tunnel feeds the steeply inclined penstock tunnel, approximately 6-feet 3-inch diameter, leading to the turbines, in which the main operating head is built up.

Between the two sections is a butterfly valve which closes automatically in the event of a burst in the lower penstocks. Adjacent to this, is an open-topped surge tank, some 18 feet in diameter. This serves the purpose of damping out surges in the tunnels, and minimises the effect of the phenomenon known as "water hammer". The latter can occur if the rate of flow to the turbines is rapidly altered following abrupt changes in the electrical load.

The inclined pressure tunnel is nearly 3,300 feet long. It derives its strength partly from its steel lining—with a maximum thickness of $\frac{7}{8}$ inch—and partly from the resistance of the rock in which it is deeply embedded. At the lower end, it branches into eight distribution pipes to feed the individual turbines in an underground power station.

The Kareeya Power Station.

The underground machine room to house the generating sets is about 45 feet wide and 230 feet long, excavated in solid rhyolite rock. This chamber has a vaulted concrete roof, cast against the rock, with its crown some 42 feet above the floor level. The foundations extend some 18 feet below.

Access is by a 217 feet long tunnel, some 15 feet by 16 feet in cross section, and another tunnel some 10 feet by 11 feet discharges the tailwater into the river.

Four generating sets, each of 18,000 kW (25,000 horsepower) capacity will be installed. Two are now in service, and the other two will be delivered shortly.

Each set comprises two twin-jet Pelton-type turbines, one on each side of the generator, with a common horizontal shaft. The generating voltage is 11 kV (kilovolts). A cable gallery between the access tunnel and the control room houses the machine power cables and control cables.

Substation and Transmission Lines.

Immediately downstream from the power station are the control room and outdoor step-up substation. From here high-tension transmission lines lead down the valley and up to the tableland.

Some 151 miles of single circuit 66-kV transmission lines take power from the station to Mt. Garnet and Atherton, on the tableland, and about 82 miles of double circuit 132-kV transmission lines to Innisfail and Cairns.

In addition, a double circuit 132-kV transmission line, some 160 miles long, will interconnect Kareeya with Ingham and Townsville.

Generating Capacity.

The final installed generating capacity in the Kareeya Power Station will be 72,000 kW. Allowing for one set to be held in reserve, the effective capacity will be 54,000 kW. However, the fourth set will generally be available to meet peak load demands,

Section of pipe for lining the low pressure horizontal tunnel. This pipe was fabricated on the job and will carry the water from the intake at the diversion weir to the top of the inclined high pressure tunnel.

The originally estimated output is 235 million-kWh (kilowatt hours) units per annum, based on requirements that the main storage should be operated to provide constant output during the most severe drought.

With the Townsville interconnection as a safeguard, it will be permissible to run the station with an appreciably higher average output, and to draw some energy from Townsville for a short period in the event of a critical drought.

The addition of the Tully-Cochable station, with a capacity of perhaps 15,000 kW, might add some 70 million units annually.

The final stage planned for the complete development of the project—the Tully-Nitchaga Power Station—can add about 5,400-kW capacity and increase the average annual output by an estimated 32·4 million units.

AREA TO BE SERVED.

When the scheme was first proposed, it was anticipated that the output from Tully Falls would be used to supply the demands of the Cairns Regional Electricity Board. This embraces the local authority areas of the City of Cairns, and the Shires of Mulgrave, Mareeba, Herberton, Eacham, Atherton, Johnstone, Douglas, Cardwell and Etheridge, over an area of 42,000 square miles.

The Townsville interconnection however, has greatly extended the area to be served. By means of this transmission line, any excess output from the station can supplement the power requirements of the Townsville Region, which at present derives its energy from coal fuel.

Interconnection to Reduce Generating Costs.

It is estimated that the interconnection will save about £2,400,000 in generation costs to the Townsville Board until about 1965. This represents the difference between the cost of operating and extending a steam station, and the cost of supply from Tully Falls.

Total area to benefit from the Tully Falls Supply aggregates over 47,000 square miles—well over half the area of Victoria.

AUTHORISATION OF PROJECT.

The State Electricity Commission and the Cairns Regional Electricity Board desired that the project be undertaken by the Co-ordinator-General of Public Works and the Government authorised its construction accordingly.

An Order in Council was made on 25th February, 1950, authorising the Co-ordinator-General to undertake construction of the first stage of the project under the State Development and Public Works Organisation Acts.

On 8th December, 1950, assent was given to "The Tully Falls Hydro-electric Project Act". This made specific provision for construction of the project in stages by the Co-ordinator-General; for inclusion of the works in the undertaking of the Cairns Regional Electricity Board as they become available for use; and for repayment by the Cairns Regional Electricity Board to the Government of the costs incurred in construction, less subsidy.

GOVERNMENT SUBSIDY AND COST.

The Queensland Government has approved a subsidy of $33\frac{1}{3}$ per cent. on the greater part of the works comprising the first stage of the project. These include Koombooloomba Dam and the Tully Falls-Kareeya portion of the work and four generating sets with a total capacity of 72,000 kW.

These works were originally estimated to cost £8,828,000 excluding interest at the price level ruling at 31st July, 1949, when the basic wage was £6 3s. 0d. per week. Since then the basic wage has risen to over £12, and for most of the construction period it exceeded £11 5s. 0d.

The estimated cost for completion of Stage 1 of the work is now £14,600,000 apart from capitalised interest. This compares favourably with the original estimate when allowance is made for rising costs. In addition the Townsville interconnection is estimated to cost some £1,756,000.

CONSTRUCTING AUTHORITY.

The Co-ordinator-General exercised a general control of design and construction, but sections of the project were delegated to appropriate authorities.

The Department of Main Roads built some of the access roads and bridges, and others were completed by the Co-ordinator-General's Department. The Engineering Office of the latter Department also carried out the major portion of the civil engineering design.

Responsibility for the mechanical and electrical sections of the project, including the provision and installation of generating plant and other electrical equipment, and the survey, design and erection of transmission lines has been delegated to the Cairns Regional Electricity Board. The Board is working in close collaboration with the State Electricity Commission.

Contracts were let to a number of firms for the supply of generating sets, switchgear, cables, transformers and other equipment, and the erection of the transmission line.

Of the civil sections under the direct control of the Co-ordinator-General's Department, Koombooloomba Dam is being built by day labour. Other sections were largely constructed by contract, although some were completed by the Department.

Contracts were let for the construction of the diversion weir, intake structure, tunnel, surge tank, power station, control building and switchyard.

PROGRESS OF WORK.

Early provision of extra generating plant was essential for the Cairns Region. Efforts were first directed towards the construction of the diversion works, tunnels and conduits, the first two generating sets and the transmission system, since in any normal year a considerable amount of energy is available from the normal flow of the river unregulated by the storage dam. No. 1 generating set first came into service on low output on 10th July, 1957.

The Townsville interconnection should be complete by 1958, and the remaining two 18,000-kW generating sets should be installed and put into service in 1958.

For some years, work on Koombooloomba Dam could proceed only at a moderate tempo because of other committments and shortages of materials and labour. However, the construction of the larger saddle dam was completed in December, 1955, and by mid 1957 the difficult and slow foundation work for the right half of the main dam had been successfully carried out.

With most other works for the project now complete or nearing completion, it has been possible to concentrate efforts on the main dam, and by 30th June, 1957, 25,000 cubic yards of concrete had been placed with construction proceeding rapidly.

It is anticipated that the dam will be effective for early storage by June, 1959, after which the output from the Kareeya station is unlikely to be seriously affected by dry weather.

ELECTRICITY SUPPLY—CAIRNS DISTRICT.

Milestones in Progress.

The three main milestones in the history of electricity supply in the Cairns District beyond the initial supply by alternators driven by reciprocating steam engines have been—

(1) The commissioning of a Hydro-electric Power Station at Barron Falls. (This Station was put into operation by the Governor of Queensland, the late Sir Leslie Orme Wilson, on 20th November, 1935. The plant was run in parallel with the Cairns Steam Station until 17th December, 1935, when the whole of the load was taken over by Barron Falls. During its first year of operation the maximum demand was 1,250 kW and 4,009,015 units were generated and 3,182,797 units were sold for an amount of £54,551 11s. 4d. The average price realised per unit sold was 4·113d. The number of consumers was 3,568.)

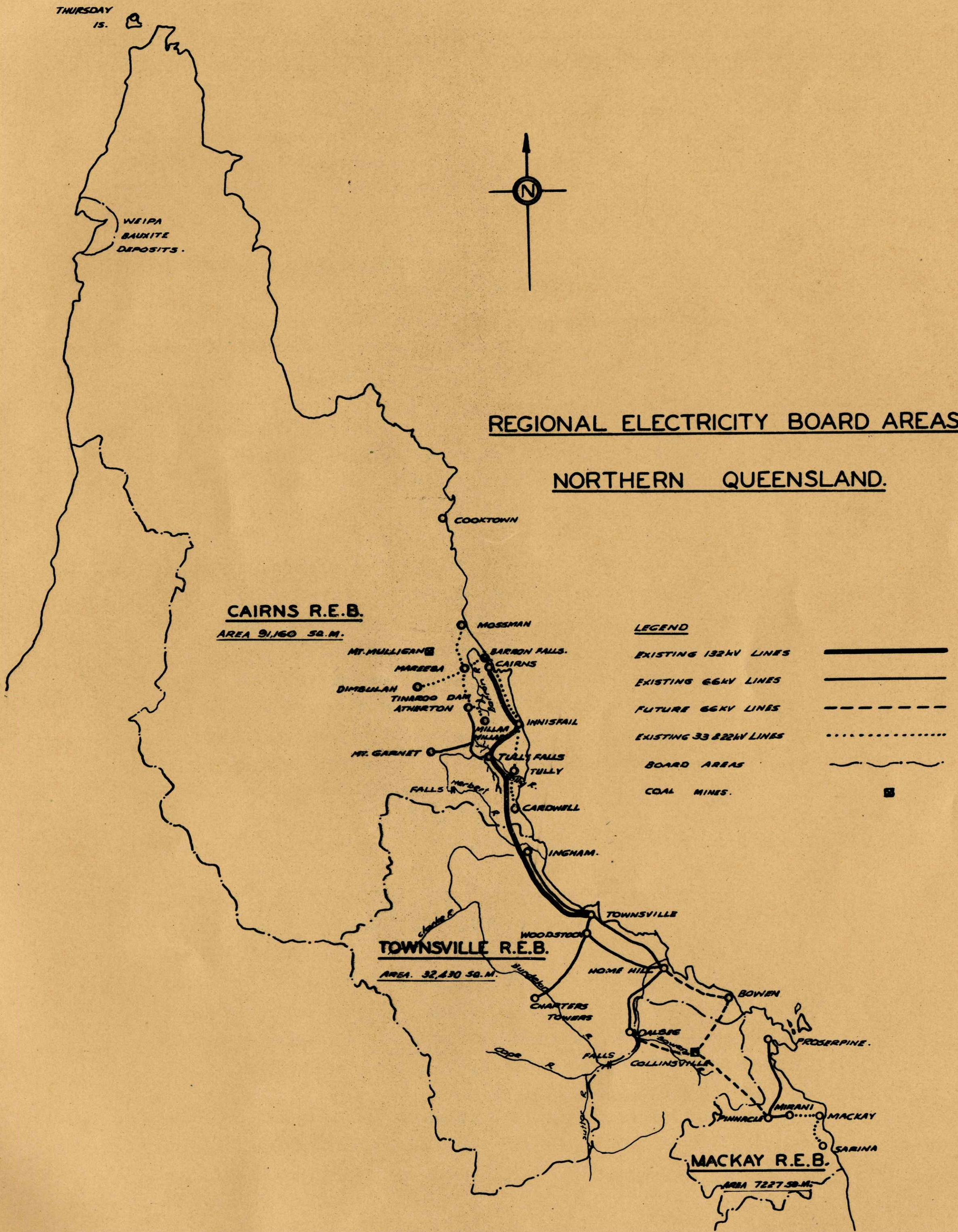
(2) The first year of operation as a Regional Board. (For the year ended 30th June, 1947, 25,684,151 units were generated or purchased. Of these units, 21,044,900 were generated at Barron Falls, and the system maximum demand was 5,350 kW. The number of units sold to 10,705 consumers was 20,950,344, for which £165,774 2s. 10d. was paid, giving an average price per unit sold of 1·895d.)

(3) The commissioning of Kareeya Power Station. (The first power was produced on 10th July, 1957, and already the system peak load has risen from 19,050 kW recorded for the financial year just ended to 22,600 kW. About half of this increase can be attributed to new tin dredge loading, and the remainder is demand which previously could not be met on peak loads because of insufficient generating capacity.)

Financial Aspects.

For the financial year ended 30th June, 1957, 93,717,583 units were generated or purchased. Of these 79,998,097 were sold for £862,685 1s. 1d. at an average price of 2.636d. There were 18,620 consumers. Barron Falls generated 33,931,100 of these units. The remainder were generated by Diesel plant or purchased from sugar mills.

It is interesting to note that although the price per unit for the year just past is roughly 38 per cent. higher than in 1947 when almost all power was produced by hydro plant, it is only 64 per cent. of the price paid in 1936.



REGIONAL ELECTRICITY BOARD AREAS.
NORTHERN QUEENSLAND.
THURSDAY IS.
WEIPA BAUXITE DEPOSITS.
COOKTOWN
CAIRNS R.E.B.
AREA 91,160 SQ. M.
MOSSMAN
MT. MULLIGAN
BARRON FALLS.
CAIRNS
MAREEBA
DIMBULAH
TINAROO DAM
ATHERTON
INNISFAIL
MILLAA MILLAA
MT. GARNET
TULLY FALLS
TULLY
FALLS
Herbert
R.
CARDWELL
INGHAM.
TOWNSVILLE
WOODSTOCK
TOWNSVILLE R.E.B.
AREA. 32,430 SQ. M.
Burdekin
HOME HILL
BOWEN
CHARTERS TOWERS
PROSERPINE.
Cape R
FALLS
COLLINSVILLE
Suttor R
MIRANI
PINNACLE
MACKAY
SARINA
MACKAY R.E.B.
AREA 7227 SQ. M.
LEGEND
EXISTING 132kV LINES
EXISTING 66kV LINES
FUTURE 66kV LINES
EXISTING 33 & 22kV LINES
BOARD AREAS
COAL MINES.

MAIN CONTRACTORS AND PRINCIPAL SUB-CONTRACTORS.

CIVIL ENGINEERING WORKS.

Queensland Contractors Pty. Ltd., Brisbane.—Constructed the diversion weir, intake works, tunnel excavations and the greater part of the underground machine room.

Electric Power Transmission Pty. Ltd., Sydney.—Constructed the 132-kV transmission lines, and supplied and erected fabricated steel in the Kareeya and step down sub-stations; constructed the switchyards and completed part of the underground machine room including the turbo-alternator foundations.

Sulzer Bros. of Winterthur, Switzerland.—Supplied and erected the high tensile steel linings in the inclined pressure tunnels.

The principal Civil Engineering Sub-Contractors were: H. J. Taylor & Son, Brisbane, who constructed the Control Building; and Scotts of Ipswich, who fabricated and erected the mild steel horizontal tunnel lining, and made gates and equipment for the intake and diversion weir.

Sub-Station Construction was performed by T. J. Watkins, Pty. Ltd. Cairns.

TURBO-ALTERNATORS.

The English Electric Co. Ltd. supplied the 18,000-kW turbo-alternator sets, the turbine control panels, the 11/132-kV transformers at Kareeya, and certain relay equipment.

MECHANICAL AND ELECTRICAL EQUIPMENT.

A large number of Australian and overseas firms supplied equipment and services to the project, principal amongst them being:—

A. Reyrolle & Co. Pty. Ltd.—11-kV and 22-kV and low-tension switchgear for the main sub-station and 132-kV oil circuit breakers.

A.S.E.A. Sweden.—66-kV oil circuit breakers.

A.S.E.A. Electric Aust. Pty. Ltd.—132-kV and 66-kV current and potential transformers.

Magrini, Italy.—Main control panels.

British General Electric Co. Pty. Ltd.—Carrier current equipment and control panels.

Gibson Battle & Co.—Self cleansing screens in intake and oil treatment plant.

Glenfield and Kennedy Ltd.—Butterfly and antisyphonic valves on the pressure tunnel.

Bryce Electric Construction Co. Ltd.—11/66-kV transformers.

Crompton Parkinson (Aust.) Pty. Ltd.—11/22-kV transformers.

Stothert & Pitt (Aust.) Pty. Ltd.—Sixty ton gantry crane for the machine room.

Hackbridge & Hewittic Electric Co. Ltd.—Shunt reactors and step down transformers for the Townsville Interconnection.

Wormald Bros. (Qld.) Pty. Ltd.—" Mulsifyre " and other fire protection equipment.

British Insulated Callenders Cables (Aust.) Pty. Ltd.—" P.B." steel poles for 66-kV transmission lines.

Alconac Pty. Ltd.—Stockbridge damper vibration recorder.

Westinghouse Rosebery Pty. Ltd.—Relay equipment.

Elecman Ltd.—Insulators and accessories.

Acelec Pty. Ltd. and D. E. Taplin Pty. Ltd.—Airbreak outdoor switchgear.

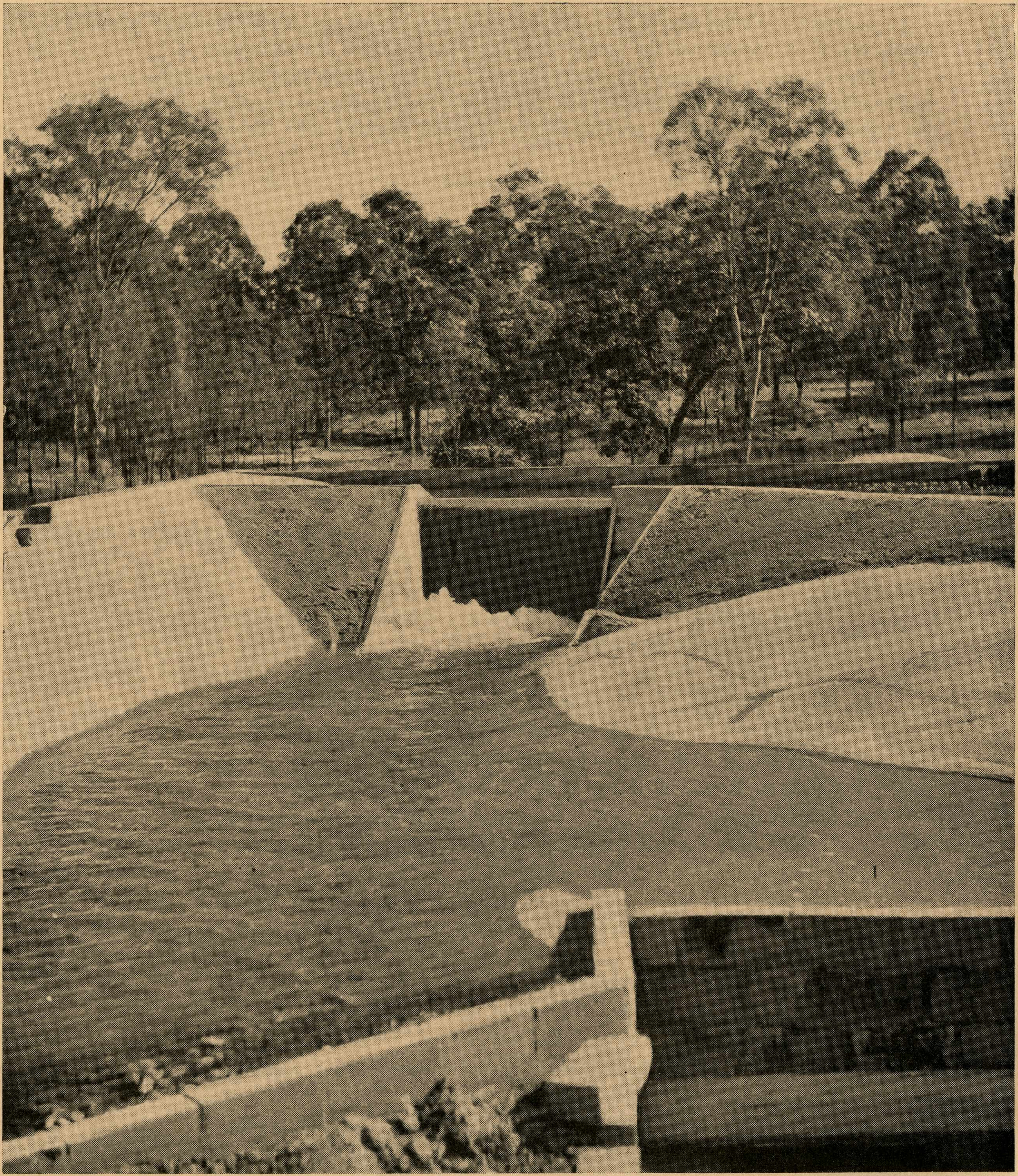
Brown Boveri and A.S.E.A.—Lightning arrestors.

Siemen's Schuckert (A/asia) Pty. Ltd.—Frequency control equipment.

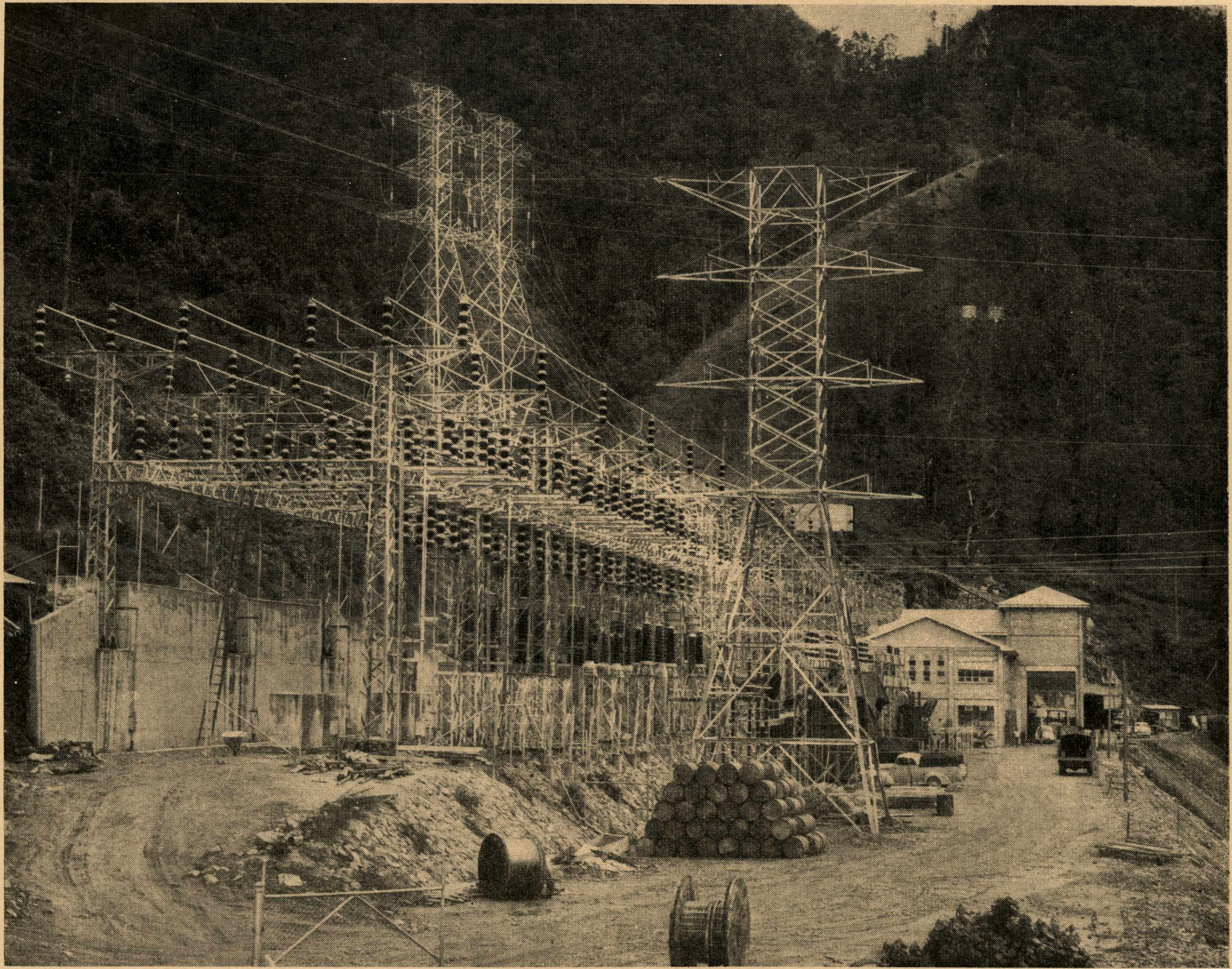
Carrier Air Conditioning Ltd.—Air conditioning and ventilation equipment.

Further works and services included the supply and installation of power and control cables by W. T. Henley's Telegraph Works Co. Ltd., Olympic Cables Pty. Ltd., Cable Makers Aust. Pty. Ltd., and Liverpool Electric Cable Co. Ltd.

The main sub-station transformers were supplied by Messrs. Brush Electrical (Australia) Pty. Ltd. and Noyes Bros. (Sydney) Ltd.



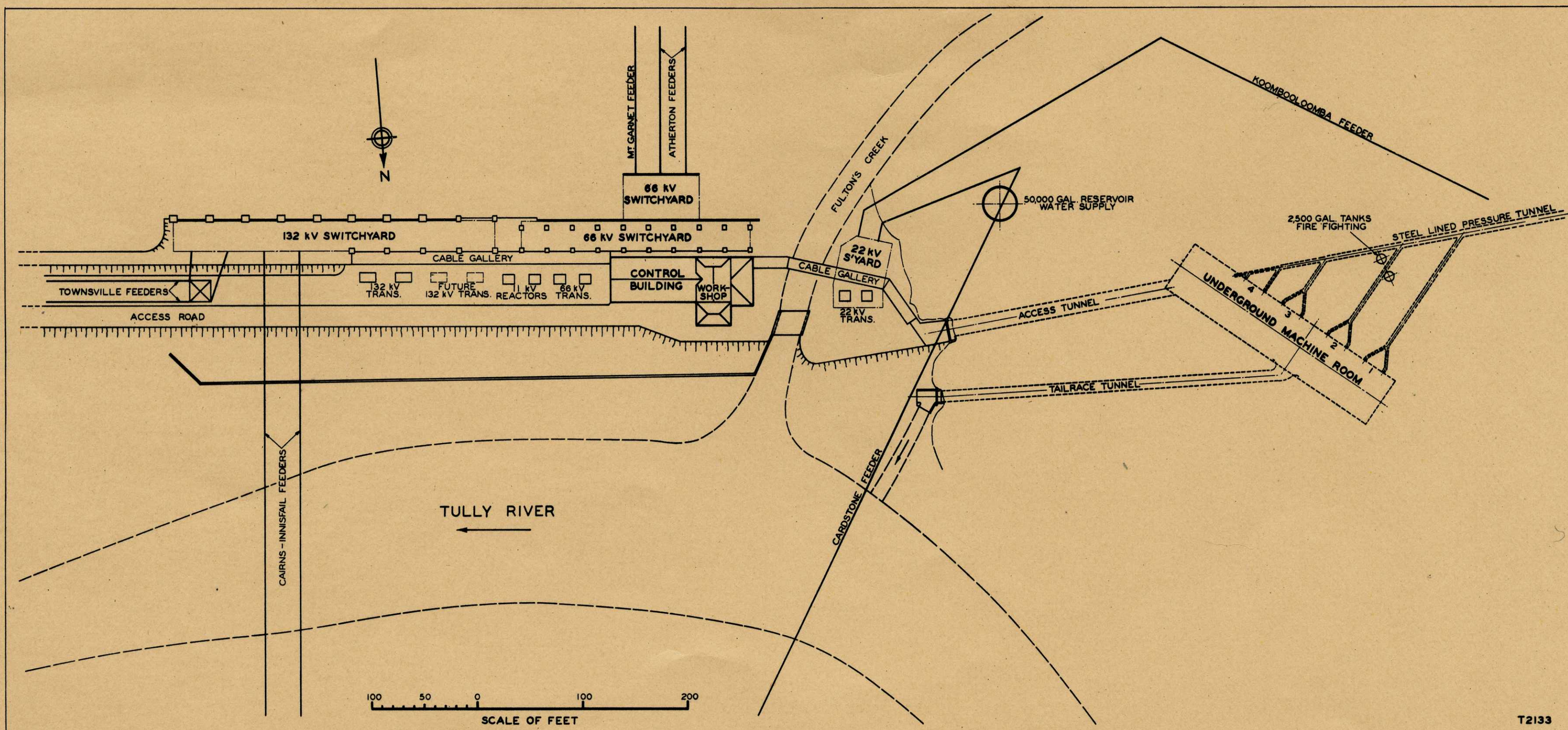
Model of Koombooloomba Dam in hydraulic laboratory, University of Queensland, St. Lucia. View shows the equivalent of a medium flood spilling over the dam.



Tully Falls Hydro-Electric Project—Kareeya Switchyard.

[*Photo by courtesy Adelie Hurley.*

A. H. Tucker, Government Printer, Brisbane.



GENERAL LAYOUT OF KAREEYA POWER STATION.